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A WATER QUALITY STUDY OF THE UPPER CLARK FORK RIVER AND SELECTED TRIBUTARIES

Environmental Protection Agency
Denver, Colorado

September 1972

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ENVIRONMENTAL PROTECTION AGENCY

A WATER QUALITY STUDY OF THE UPPER CLARK FORK RIVER AND SELECTED TRIBUTARIES

REGION VIII

DENVER, COLORADO

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The specific objectives of the study were to determine the present water quality and biological conditions in the Clark Fork River between Warm Springs & Drummond, Montana and to determine the allowable concentrations of metals & other constituents that will protect the established beneficial uses for the Clark Fork River at Warm Springs.

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* Water quality
* Metals

17b. Identifiers/Open-Ended Terms

* Biological Conditions
* Clark Fork River

Metallic concentrations.

17c. COSATI Field/Group

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INTRODUCTION

I. Statement of Problem

The Clark Fork River in western Montana is the major stream in that region of the State and is of primary importance to the area. The waters are heavily utilized for recreational, agricultural, industrial, and other uses at many points. Many of these uses impose waste loads on the stream. The most significant of these, in terms of adverse impact on water quality, has been the waste load from mining operations.

For the past eighty to one hundred years, wastes from the copper mining, milling, and smelting operations in the Butte and Anaconda area have been discharged to the Clark Fork River. In the past, these wastes created conditions toxic to fish and other biological forms as far downstream as Missoula, a distance of one hundred miles. In more recent years, operational improvements and waste treatment facilities installed by the companies have greatly improved the quality of the stream. There are still, however, significant water quality problems attributable to the mining operations.

In 1967, the Montana Water Pollution Control Council, as part of their continuing program of protecting and improving water quality, established water quality standards for the surface waters of Montana. These standards established beneficial uses to be protected but did not specify numerical criteria for heavy metals and other associated contaminants. For the Clark Fork River, the established beneficial uses are recreation including swimming, growth and marginal propagation of salmonid fish,

and agricultural and industrial water supplies in the reach from Warm Springs Creek to the mouth of the Little Blackfoot River. In the reach from the mouth of the Little Blackfoot River to the Idaho-Montana State border, the uses are public water supply, recreation including swimming, growth and propagation of salmonid fish and agricultural and industrial water supplies. Applicable water quality standards for these reaches are listed in Tables I and II.

The Montana State Department of Health and Environmental Sciences, the agency responsible for administering the standards, soon recognized the need to establish heavy metal standards criteria on the Clark Fork River in order to protect the beneficial uses and establish the required treatment levels for the mining operations near Butte and Anaconda. In March, 1970, the Montana State Department of Health and Environmental Sciences requested the Environmental Protection Agency (then the Federal Water Pollution Control Administration) to conduct bioassays or stream studies to determine the allowable maximum concentrations for heavy metals in the Clark Fork. A copy of the request is included in Appendix A. This report documents the results of those studies.

II. Objectives

The specific objectives of this study were:

1. What are present water quality and biological conditions in the Clark Fork River between Warm Springs and Drummond, Montana?

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Stream Reach	Criteria Classification		Dissolved Oxygen	pH	T
		Organisms of the coliform group by the most probable numbers (MPN) or equivalent membrane filter (MF) methods, during any consecutive 30-day period and using a representative number of samples, shall:	Milligrams per liter (MG/L); No reduction shall be allowed below the listed minimum concentrations	Induced variation within listed range shall be less than 0.5 pH unit. Natural pH outside listed range shall be maintained without change. Natural pH above 7.0 shall be maintained above 7.0	A i t n o t
Silver Bow Creek (upper extension of the Clark Fork River) from the confluence of the Yankee Doodle and Blacktail Deer Creeks to Warm Springs Creek	Classified for industrial waste use	------	--	------	
Clark Fork River from Warm Springs Creek to mouth of Little Blackfoot River	$C\text{-}D_2$ 1/*	Average less than 1000/100 ml, where demonstrated to be the result of domestic sewage, with not more than 20% of the samples exceeding this value	6 mg/l	6.5 to 9.0	10
From the mouth of the Little Blackfoot River to the Idaho-Montana State border	$B\text{-}D_1$ 2/*	(Same as Above)	7 mg/l	6.5 to 8.5	5

* Footnotes attached

TABLE I

STATE OF MONTANA WATER POLLUTION CONTROL COUNCIL WATER QUALITY CRITERIA
APPLICABLE AFTER REASONABLE OPPORTUNITY FOR DISCHARGES TO MIX WITH
RECEIVING WATERS AS DETERMINED BY THE MONTANA WATER POLLUTION CONTROL COUNCIL

pH	Turbidity	Temperature (°F)	Residues	Sediment or Settleable Solids	
Induced variation within listed range shall be less than 0.5 pH unit. Natural pH outside listed range shall be maintained without change. Natural pH above 7.0 shall be maintained above 7.0	Allowable increase to naturally occurring turbidity	Allowable changed to naturally occurring water temperature	Oils, floating solids and sludge deposits. Allowable increase above naturally occurring concentrations	Allowable increase above naturally occurring concentrations	Toxic or other deleterious substances, pesticides and organic and inorganic materials including heavy metal compounds. (Exceptions for beneficial purposes may be authorized by the Montana Water Pollution Control Council or the Environmental Protection Agency
------	--	-----	-----	------	----------
6.5 to 9.0	10 JCU	Increases: 32° to 67° : 2° Max. Above 67° : 0.5° Max. Decreases: Over 55° 2° per hr. 55° to 32° : 2° Max. Provided that water temperature must be below 40° during the winter season & above 44° during the summer season	None in sufficient quantities to adversely affect the use indicated	None in sufficient quantities to adversely affect the use indicated	Maximum allowable concentrations shall be less than acute or chronic problem levels as revealed by bioassay or other appropriate methods. In no case shall the following be exceeded: one-tenth of the 4-day median tolerance limit (TLM96) for short residual materials, and one-hundredth (0.01) of the TLM96 for pesticides and organic materials exhibiting a residual life exceeding 30 days in water
6.5 to 8.5	5 JCU	(Same as Above)	(Same as Above)	(Same as Above)	(Same as Above)

IL

or s Solids		Radioactivity	Aesthetic Considerations Not Covered Under Other Water Quality Criteria
increase urally concen-	Toxic or other deleterious substances, pesticides and organic and inorganic materials including heavy metal compounds. (Exceptions for beneficial purposes may be authorized by the Montana Water Pollution Control Council or the Environmental Protection Agency	(Limits listed shall include natural background)	
--	----------	------	----------
efficient s to ad- ffect ndicated	Maximum allowable concentrations shall be less than acute or chronic problem levels as revealed by bioassay or other appropriate methods. In no case shall the following be exceeded: one-tenth of the 4-day median tolerance limit (TLM96) for short residual materials, and one-hundredth (0.01) of the TLM96 for pesticides and organic materials exhibiting a residual life exceeding 30 days in water	Concentrations of radioactive materials shall conform with the 1962 U.S.Public Health Svc Drinking Water Stds. Except where concentration factors of aquatic flora and fauna exceed the recommended reduction factors* then maximum permissable limits shall be reduced below acute or chronic problem levels. *USPHS Drinking Water Standards.	No wastes (including phenolic compounds and visible oils), offensive to the senses of sight, touch, smell, or taste, not attributable to natural causes, shall be allowed. No excess nutrients which cause nuisance aquatic growths. Taste and odor causing materials shall not exceed levels which cause taining of the flesh of edible species. Real color shall not exceed 5 units above naturally occurring color.
bove)	(Same as Above)	(Same as Above)	(Same as Above)

Attachment to Table I

Footnotes:

1/ Classification C-D_2. The quality of these waters shall be maintained suitable for bathing, swimming, and recreation; growth and marginal propagation of salmonid fish and associated aquatic life, waterfowl, and furbearers; agricultural and industrial water supply. Therefore, "C-D_2" equals "C", "D_2", "E", and "F".

2/ Classification B-D_1. The quality of these waters shall be maintained suitable for drinking, culinary, and food processing purposes after adequate treatment equal to coagulation, sedimentation, filtration, disinfection, and any additional treatment necessary to remove naturally present impurities; bathing, swimming and recreation (see Note under "A-Open-D_1); growth and propagation of salmonid fish and associated aquatic life, waterfowl, and furbearers; agricultural and industrial water supply. Therefore, "B-D_1" equals "B", "C", "D_1", "E", and "F".

TABLE II

IMPLEMENTATION SCHEDULES FOR UPPER CLARK FORK AREA

City or Industry	Treatment Need	Construction Time Schedule				
		Eng. Report	Arr. of Financing	Const. Plans	Start Const.	Placed in Operation
Butte Metropolitan Sewer District	Secondary sewage treatment	C O M P L E T E D				
Missoula	Secondary sewage treatment	7/1/69	1/1/70	7/1/70	1/1/71	7/1/72
Anaconda Copper Co.	Needs to be determined.1/ Order issued by State Board of Health for compliance with standards.	(See comment below)				

* 1/ Adequate safeguards and procedures will be incorporated into the treatment system to protect the water quality of the Clark Fork River below Warm Springs at all times. Immediate consideration shall be given to correcting:

a. Deficiencies of winter-time operation, spills due to wind action, temporary bypassing of wastes, or any other cause of waste spills.

b. Disruption of normal operation by periodic labor disputes or any other causes. (These preventative measures will be taken no later than July 1968.)

*NOTE: As a further step toward improving water quality in the Clark Fork River, the State of Montana in 1969 established a July, 1972, date for total water quality standards compliance by the Anaconda Copper Company. By this date the Company is to complete the treatment facilities needed to provide adequate treatment for all their wastes.

2. What are the allowable concentrations of metals and other constituents that will protect the established beneficial uses for the Clark Fork River at Warm Springs, Montana?

III. Approach

Since the personnel and resources were not available to conduct bioassay studies, it was decided that stream studies would be conducted to determine the water quality in the Clark Fork River reaches at points where the specified beneficial uses existed. The average heavy metal(s) concentrations at those points would then be recommended as the allowable average daily concentrations to be included in the water quality standards.

This method has both advantages and disadvantages as compared to the bioassay studies. A major advantage is that it is almost impossible to include all of the water quality variables in a laboratory study while the condition of the biological community at any point in the stream is indicative of the cumulative and long-term effects of variations in water quality. Conversely, a major disadvantage is that heavy metal concentrations and other water quality parameters in a stream do not remain constant during any established period. Also, stream surveys are easily and severly affected by extremes in natural conditions and accidental spills or discharges; however, this survey was not so affected and the resultant data are considered to be reliable for establishing water quality standards.

IV. Scope of Study

The study involved extensive water quality sampling and biological evaluations in the reach of the Clark Fork from Warm Springs to Drummond, Montana, and in selected tributaries. The field work was conducted during the period from May through November, 1970. Data from previous studies in the area were also reviewed.

V. Authority

The Federal Water Pollution Control Act, as amended, provides authority for studies of this type.

VI. Acknowledgements

All field and laboratory work discussed in this report was accomplished by personnel of the Pacific Northwest Region, Federal Water Quality Administration, now Region X, EPA. The cooperation of the Montana State Department of Health and Environmental Sciences, the Montana Department of Fish and Game, and the Anaconda Corporation is appreciated.

SUMMARY AND CONCLUSIONS

Analyses of the chemical and biological samples collected during the survey, and of the 1969-1970 population data indicates that:

1. The Clark Fork River above Deer Lodge is severely polluted as indicated by a deficient and non-balanced population of benthic organisms and an almost nor-existent fish population.

2. Populations of benthic organisms at and below Garrison are generally representative of a healthy, well-balanced biological system with significant numbers of many forms being present.

3. Fish populations in the Clark Fork gradually increase from Dempsey downstream and below Drummond the stream supports significant sportfishing activity.

4. Wastes discharge from the Anaconda Company settling ponds are the principal cause of the high concentrations of most metals and other constituents in the Clark Fork at Warm Springs. These high concentrations gradually decrease downstream, approaching tributary water quality in the Clark Fork River below Drummond. Also, these waste discharges have caused the "cementing" of the river bottom from the Anaconda Company settling ponds downstream to between Dempsey and Deer Lodge. This cementing is caused by the precipitation of the gypsum and metalic hydroxides in the settling pond discharges.

5. Chemical and biological conditions in the streams tributary to the Clark Fork within the study area are indicative of high quality water.

6. Waste spills from the Anaconda Company settling ponds which resulted in significant increases in metal concentrations in the receiving water were observed on several occasions.

7. The beneficial uses designated in the approved standards for the Clark Fork River between the mouth of Warm Springs Creek and the mouth of the Little Blackfoot River are supported by present average water quality conditions at Garrison, Montana.

8. The beneficial uses designated in the approved standards for the Clark Fork River below the mouth of the Little Blackfoot River are supported by present average water quality conditions at Drummond, Montana.

9. The lead concentrations found in the trout tissues from both the mainstem of the Clark Fork River and the tributaries (Appendix D-2), indicate a potential hazard to either health or fish propagation. Therefore, further water quality analyses and bio assays on the Upper Clark Fork and tributaries are necessary to determine the degree of the hazard related to these lead concentrations and develop an appropriate control strategy.

RECOMMENDATIONS

1. To protect the beneficial uses specified by the Montana Water Quality Standards classification of the Clark Fork River, the following standards are recommended:

a. For the reach of the Clark Fork from the mouth of Warm Springs Creek, to the mouth of the Little Blackfoot River, which is presently classified C-D_2.

	Average Daily Concentration ug/l	Maximum Instantaneous Concentration ug/l
Total Copper	90	180
Dissolved Copper	30	40
Total Zinc	200	600
Dissolved Zinc	80	140
Total Iron	1,300	2,200
Dissolved Iron	150	160
Total Lead	100*	100*
Dissolved Lead	100*	100*
Total Cadmium	10*	10*
Total Arsenic	10	16
Total Mercury	1	1

* The levels specified above for lead and cadmium are recommended as interim standards. Additional sampling is necessary to establish the final levels for these parameters.

b. For the reach of the Clark Fork from below the mouth of Little Blackfoot River to the Montana-Idaho State line, which is presently classified B-D_1.

	Average Daily Concentrations ug/l	Maximum Instantaneous Concentrations ug/l
Total Copper	50	90
Dissolved Copper	30	30
Total Zinc	100	200
Dissolved Zinc	70	80
Total Iron	300	1,300
Dissolved Iron	150	150
Total Lead	50*	50*
Dissolved Lead	50*	50*
Total Cadmium	10*	10
Total Arsenic	10	10
Total Mercury	1	1

* The levels specified above for lead and cadmium are recommended as interim standards. Additional sampling is necessary to establish the final levels for these parameters.

2. In conjunction with the adoption of the standards recommended above, it is recommended that the State of Montana initiate action to upgrade the classification of the Clark Fork River reach from the mouth of Warm Springs Creek to the mouth of the Little Blackfoot River from C-D_2 to C-D_1.

3. A joint Federal/State water quality survey to establish the maximum allowable concentration of lead and cadmium in the Upper Clark Fork River Basin, be scheduled for the period of January - December 1973. This survey should include bio assays and toxicology studies sufficient to develop final lead and cadmium standards for the Upper Clark Fork River.

4. The survey requested by the State of Montana on the water quality problems of the Silver Bow Creek area between Butte and Warm Springs should be completed by the Environmental Protection Agency, Region VIII, by September 1972, so that the State of Montana can reclassify the Silver Bow Creek area for other than industrial use.

DESCRIPTION OF STUDY AREA

I. General

The Clark Fork River is located in the northern Rocky Mountain physiographic province of western Montana. It begins in the granite hills near Butte, flows generally northwest about 520 miles and terminates in Lake Pend Oreille. From the headwaters to Warm Springs, Montana, the stream is called Silver Bow Creek (see Figure 1).

The section of the Clark Fork River between Warm Springs and Garrison, Montana, which is the principle area covered by this study, flows through Deer Lodge Valley (a broad intermontane valley). This north-south trending valley is six to ten miles wide and about 25 miles long. It is bordered on the east by the Continental Divide and on the west by the Flint Creek Range.

The Deer Lodge Valley is partially filled by a thick layer of well-sorted silt, sand, gravel and clay. This fill has been eroded into extensive terraces which border both sides of the valley below Warm Springs, Montana. The broad floodplain of the Clark Fork is underlain by a thin deposit of poorly sorted silt, sand and gravel alluvium. Bedrock forming the surrounding mountains and underlying the unconsolidated valley fill is composed of sedimentary, igneous and metamorphic rocks.

The area is characterized by long, cold winters and low precipitation. January is generally the coldest month, with the temperatures averaging below freezing. Most of the precipitation occurs during the

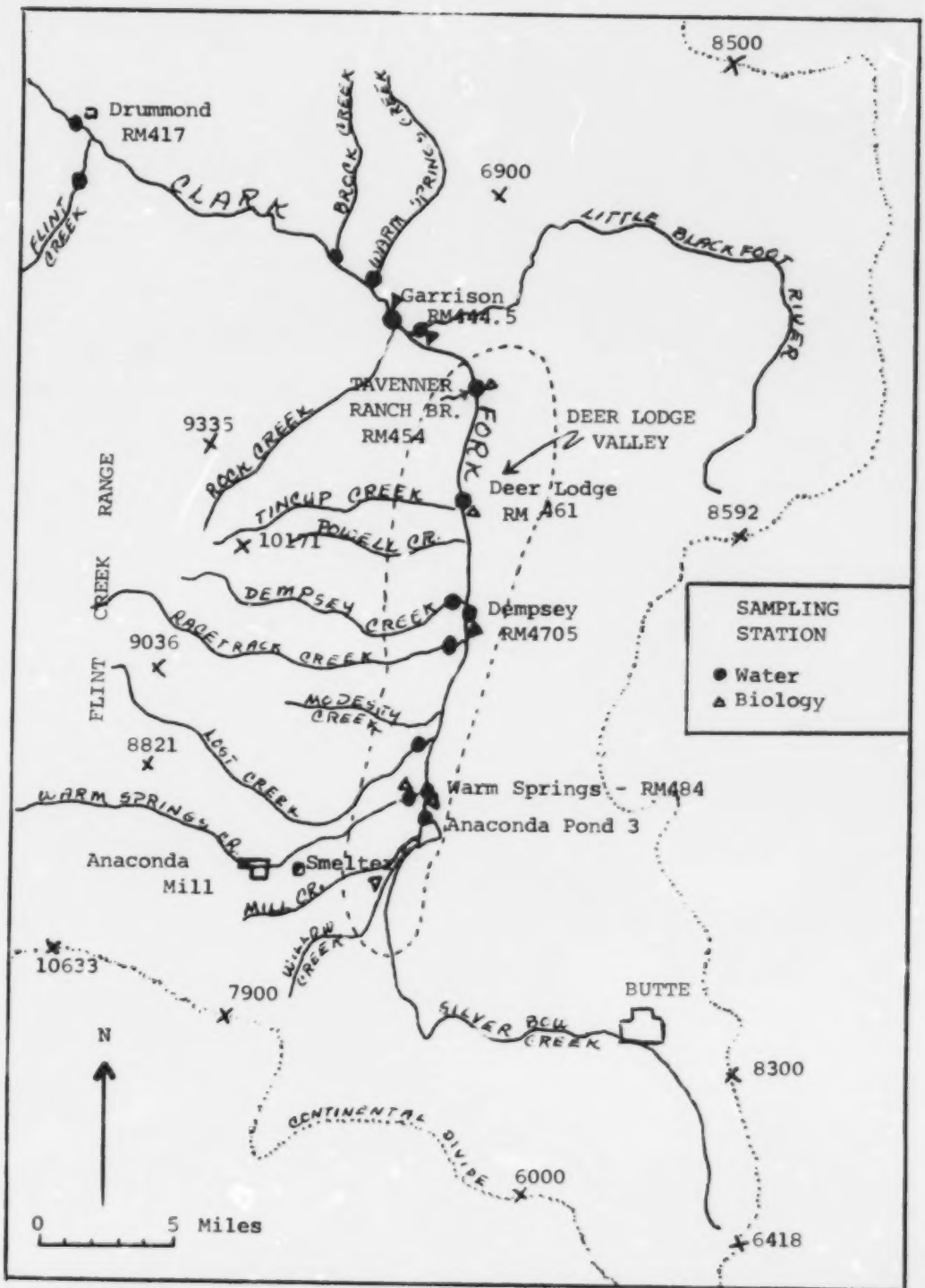

FIGURE 1. Map of the Upper Clark Drainage Basin showing water quality monitoring stations.

spring and summer months with June generally being the wettest month. Strong winds are also common in the area.

II. Hydrology

Silver Bow Creek flows west from Butte through a narrow valley and enters the southern end of Deer Lodge Valley where, after combining with some other small creeks, it becomes the Clark Fork River. The Clark Fork River then flows north for about 30 miles to the confluence with the Little Blackfoot River at Garrison, Montana. The river then flows northwesterly on through another narrow valley toward Missoula, Montana.

There are two major tributaries to the Clark Fork in the study area below the Deer Lodge Valley. These are the Little Blackfoot River which enters just upstream from Garrison, Montana, and Flint Creek which enters just upstream from Drummond, Montana. Also, numerous tributaries to the Clark Fork River originate in the Flint Ridge Range and flow eastward into the Deer Lodge Valley. These streams include Lost, Modesty, Racetrack, Dempsey, Powell, Tincup, and Rock Creeks.

The available stream flow data for the Upper Clark Fork drainage is meager. A general estimate of the average flow characteristics in the mainstem is shown in Table III. The data in this table are estimates based on some flow measurements and observations by experts in stream flow measurement from the U.S. Geological Survey (USGS). In general, peakflows coincide with the spring runoff and low flows occur in the fall and early winter.

TABLE III

FLOW ESTIMATES FOR CLARK FORK AND TRIBUTARIES

Station	Estimated Mean Monthly Flow - (1970), cfs					
	May	June	July	August	September	October
Clark Fork - Gregson	250	300	110	50	45	50
Clark Fork - Opportunity	310	370	150	60	50	60
Willow Creek - I-90	60	70	25	11	10	11
Mill Creek - I-90	70	80	30	15	13	15
Warm Springs Creek - (mouth)	70	80	30	13	10	13
Clark Fork - Warm Springs	450	500	300	200	150	200
Lost Creek - I-90	150	200	100	50	40	50
Racetrack Creek - I-90	100	125	25	10	9	10
Clark Fork - Dempsey	480	600	300	200	180	230
Clark Fork - Deer Lodge	500	650	350	225	200	250
Clark Fork - near Garrison	600	700	380	250	210	260
Little Blackfoot River - (mouth)	350	400	150	80	60	70
Clark Fork - near Garrison	1000	1400	550	300	250	325
Warm Springs Creek - Garrison	20	40	20	10	8	9
Gold Creek near Gold Creek	80	100	40	16	14	16
Brook Creek - I-90	10	12	5	2	1.5	2
Clark Fork at Drummond	1750	1900	1200	500	450	650
Flint Creek - (mouth)	250	350	200	150	100	150

In the Deer Lodge Valley reach the flow of the Clark Fork more than doubles during high flow periods and quadruples during low flow periods. The greater increase during the low flow period is principally due to the discharge of ground water from the unconsolidated valley alluvium.

III. Water Uses

The largest water user in the Upper Clark Fork River area is the Anaconda Company operations at Butte, Montana, and at the copper smelter located in Anaconda, Montana. A total of about 80 million gallons per day (mgd) is used at the smelter primarily in the flotation type concentrators of which approximately 25 mgd is recycled process water and 55 mgd is make-up water from Warm Springs Creek and Georgetown Lake. At Butte, Montana, 13-14 mgd is used for public water supply with approximately 10 mgd supplied by transmountain diversion from the headwaters of the Missouri River and the remainder supplied from storage on the headwaters of Silver Bow Creek.

Present water quality limits other uses of the Clark Fork River above Deer Lodge, Montana. Below this point there is a gradual increase in recreational and other uses, primarily fishing. Below Garrison, Montana, fishing use increases rapidly. The Montana Fish and Game Department considers the Clark Fork River downstream from Drummond, Montana, as one of the best trout streams in the State.

IV. Waste Sources

There are three treated domestic wastes discharged into the Upper Clark Fork River. Seven mgd of treated effluent are discharged from the Butte, Montana, new secondary treatment plant to Silver Bow Creek. An effluent flow of 0.2 mgd from the State Hospital treatment lagoon is discharged to the Clark Fork River downstream of the county road bridge at Warm Springs, Montana. At Deer Lodge, Montana, approximately 0.5 mgd of effluent from the town lagoon is discharged to the Clark Fork River. The municipal wastes from Anaconda, Montana, are discharged to the Anaconda Company tailings ponds.

The largest industrial discharger in the area is the Anaconda Company. At Butte, Montana, the copper precipitation process wastewater flows range from 3,000 to 5,000 gpm with a pH of about 4 and an iron concentration of more than 2,000 mg/l. The wastewater is discharged into Silver Bow Creek for transport to the settling ponds near Warm Springs, Montana, 24 miles downstream, for further treatment. The highly acidic flows in Silver Bow Creek are mixed with lime and the alkaline waste from the copper smelter at Anaconda, Montana, before reaching the settling ponds. Dependent upon pH, the ferrous or ferric hydroxide is precipitated in the settling ponds. The effluent from the settling ponds is essentially a saturated solution of calcium sulfate (gypsum) which contains varying amounts of total and dissolved metals. The variations in effluent quality are caused by process fluctuations, poor pond operation, intermittent bypassing of settling ponds, and spills or short-circuiting in the ponds due to adverse wind or ice conditions.

V. Water Quality Standards

The Montana State Department of Health and Environmental Sciences adopted water quality standards in 1967 in accordance with provisions of the Water Quality Act of 1965. These standards were formally approved by the Federal Government on February 29, 1968. For the Clark Fork River, these standards classified the reach from the mouth of the Warm Springs Creek to the mouth of the Little Blackfoot River as $C\text{-}D_2$ and the reach from the mouth of the Little Blackfoot River to the Montana-Idaho State line as $B\text{-}D_1$.

These standards consist of specified water quality criteria designed to protect water uses in the Upper Clark Fork River and an implementation plan which outlines treatment requirements and waste treatment construction schedules for the cities of Butte and Missoula, Montana, and also the Anaconda Copper Company at Butte and Anaconda, Montana.

The water quality standards criteria for the Upper Clark Fork River are summarized in Table I and the applicable implementation schedules are listed in Table II.

STUDY DESIGN

I. Water Quality Evaluation

In order to determine present water quality in the upper reaches of the Clark Fork River, nineteen sampling stations were established as shown on Figure 1. In order to evaluate water quality during both high and low flow periods, the survey was conducted from May through November, 1970. During this period sampling trips were made approximately bi-weekly with mainstem stations sampled on every trip and the tributary stations less often.

At each sampling station temperature, pH, conductivity, and alkalinity were measured at the time of sampling. Additional samples were collected for laboratory analyses including total hardness, sulfate, total mercury, total cadmium, and both total and dissolved concentrations of zinc, copper, and iron. Analyses for solids and other metallic ions were also conducted.

Appendix B to this report contains a detailed description of the station locations, sampling dates, and specific analytical methods.

II. Biological Evaluation

A. Benthic Biota. An assessment of the macroinvertebrate fishfood organisms associated with the bottom was made at five stations on the mainstream of the Clark Fork and on three tributaries as shown on Figure 1. The biological data at these points were collected by two

different sampling methods. Artificial substrates consisting of stone-filled wire baskets were placed in the stream at each sampling point. These samplers were initially installed on May 19, 1970, and the organisms were collected on June 29, August 12, and September 16, 1970. In addition, standard bottom samples using a Surber sampler were collected during the August 12, 1970, sampling trip. At each site, four distinct samples were taken and composited. In all cases, the organisms collected were preserved with 70 percent ethanol and sent to the Pacific Northwest Water Laboratory for identification.

B. Fish. In order to provide a qualitative determination of fish populations in portions of the mainstem of the Clark Fork River and selected tributaries, the Montana State Fish and Game Department conducted electrical shocking surveys during 1969 and 1970. The results of these surveys are presented in Appendix D-1. In November, 1970, similar investigations involving both EPA and Montana Fish and Game personnel were conducted on seven Clark Fork tributaries. These were Flint, Warm Springs (Powell County), Racetrack, Lost, Warm Springs (Deer Lodge County), and Willow Creeks and Little Blackfoot River. At each location qualitative evaluations were made on quantity, size, species, and general condition of the fish (see Appendix D-2).

RESULTS

I. Chemical Quality

A. Average Conditions

The general pattern of water quality in the upper Clark Fork River is apparent from the data in Table IV and Figure 2. Table IV lists the average water quality values measured at the six Clark Fork River sampling stations and the overall average values for the same parameters of the seven tributaries. Table V lists the average water quality values for the individual tributaries. Locations for all the stations indicated are shown on Figure 1. A complete summary of the data for each sampling station is available through STORET.

Concentrations of most constituents in the Clark Fork River are high at the upper end of the study area and gradually decrease downstream. Dissolved copper, dissolved iron, total mercury, and total cadmium concentrations remain essentially constant with the latter two at very low concentrations. Alkalinity and pH increase in the downstream direction.

As shown by the data in Tables IV and V, the water quality in the tributaries is much better than in the Clark Fork River. The concentrations of most constituents in the tributaries are significantly lower than at the Drummond, Montana, station which has the lowest constituent concentrations of the Clark Fork stations. The difference is particularly striking when the water quality of the tributaries is compared with the water quality of the Clark Fork stations at the upper end of the study area.

TABLE IV

AVERAGE WATER QUALITY FOR MAINSTEM CLARK FORK STATIONS

Parameter	Warm Springs RM 483.7 Average	Dempsey Creek RM 470.5 Average	Deer Lodge RM 461.2 Average	Tavenner Ranch Br. RM 453.8 Average	Garrison RM 444.5 Average	Drummond RM 417.0 Average	Average For Seven Tributaries
pH	7.2	7.2	7.2	7.3	7.4	7.9	7.8
Total Alkalinity, mg/l as $CACO_3$	47	92	109	123	120	150	159
Total hardness, mg/l	1133	764	755	623	542	434	286
Sulfate, mg/l	1233	638	515	547	397	260	88
Total Copper, ug/l	200	130	185	143	91	51	37
Dissolved Copper, ug/l	42	38	41	47	32	34	27
Total Zinc, ug/l	810	333	584	286	173	119	50
Dissolved Zinc, ug/l	432	157	141	122	83	69	30
Total Iron, ug/l	1765	1280	2167	1367	1275	530	205
Dissolved Iron, ug/l	141	170	156	157	148	144	125
Total Mercury, ug/l	0.8	0.8	0.8	0.8	0.8	0.8	1.0
Total Arsenic, ug/l	30	16	16	15	11	13	10.3
Total Cadmium, ug/l	15	<10	<10	<10	<10	<10	<10

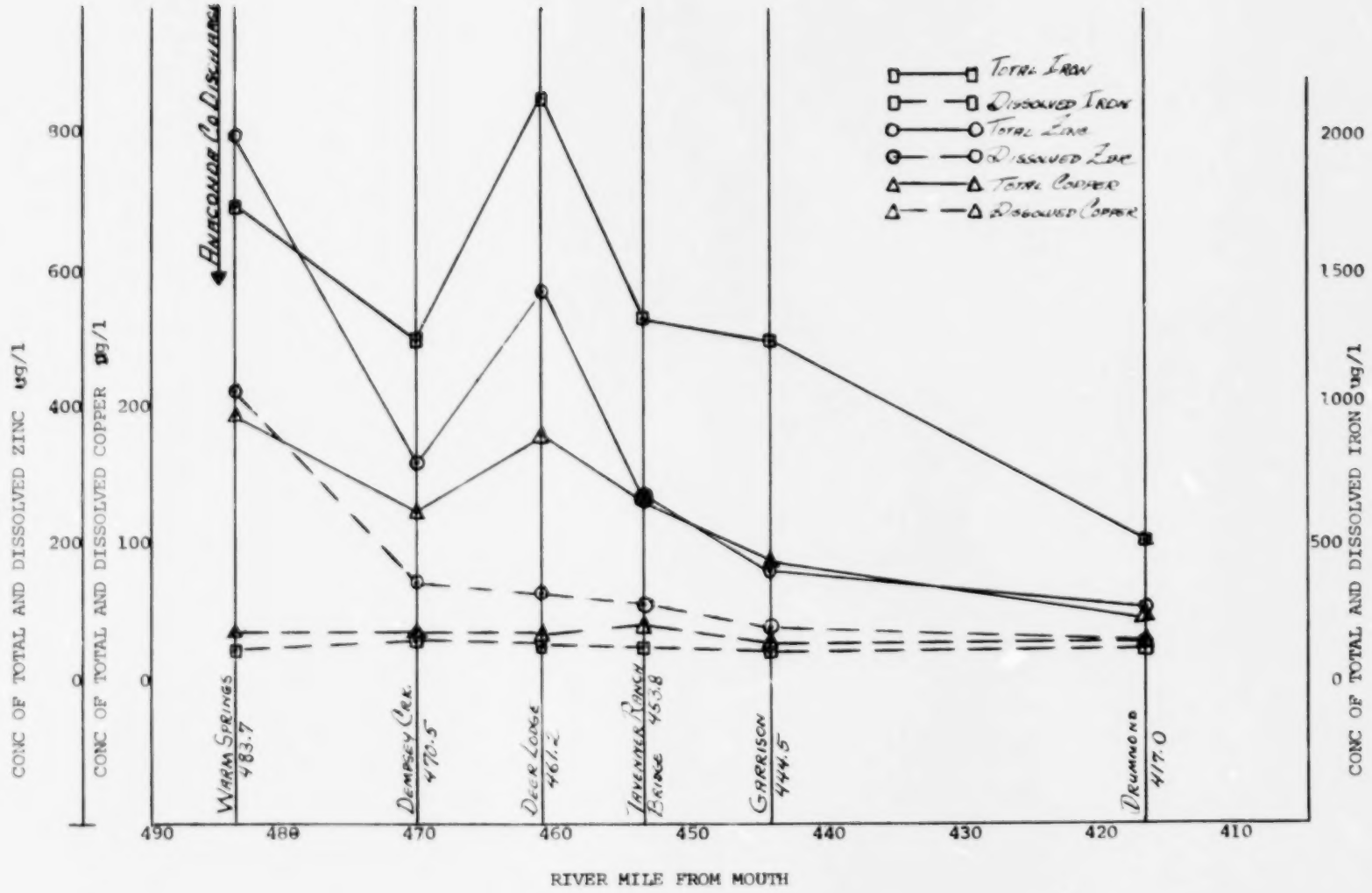

FIGURE 2. Variations in the concentrations of Heavy Metals in the Clark Fork River downstream of the Anaconda Company discharge.

TABLE V

AVERAGE WATER QUALITY OF TRIBUTARIES

Parameters	Lost Creek Average	Racetrack Creek Average	Dempsey Creek Average	Little Blackfoot River Average	Warm Springs Cr. (Powell City) Average	Brook Creek Average	Flint Creek Average
pH	8.1	7.4	7.6	7.4	8.1	8.2	7.9
Total Alkalinity, mg/l as $CaCO_3$	173	89	158	121	201	205	164
Total hardness, mg/l	305	149	412	165	473	292	216
Sulfate, mg/l	96	14	--	22	266	101	29
Total Copper, ug/l	35	32	48	37	37	37	35
Dissolved Copper, ug/l	27	22	33	26	24	29	28
Total Zinc, ug/l	38	38	108	38	33	42	55
Dissolved Zinc, ug/l	20	18	42	28	30	31	43
Total Iron, ug/l	229	174	107	796[1/]	188	258	594[2/]
Dissolved Iron, ug/l	90	107	80	171	101	160	163
Total Mercury, ug/l	1.5	1.5	0.8	0.8	0.7	0.9	1.0
Total Arsenic, ug/l	28	5	7.5	8.5	4.7	7.3	11
Total Cadmium, ug/l	<10	<10	<10	<10	<10	<10	<10

1/ Average includes two extremely high values obtained during high flow conditions. Average without these values included would be 179 ug/l.

2/ Average includes two extremely high values obtained during high flow conditions. Average without these values included would be 300 ug/l.

Usually constituent concentrations in a given stream increase in a downstream direction due to both natural and man-made causes. In the Clark Fork River a converse situation exists because substantial portions of the flow at Warm Springs are effluent from the Anaconda Company settling ponds which contains significant quantities of both dissolved and suspended contaminants; for example, note the excessively high hardness and sulfate levels. The quality of the Clark Fork River gradually improves downstream due to dilution by the tributaries. The data indicates that the downstream decrease in heavy metals concentrations probably continues below Drummond, the downstream limit of the study.

During the course of the field investigations it was also noted that from Warm Springs to somewhere between Dempsey and Deer Lodge the bottom materials were "cemented" together. The condition was most noticeable at Warm Springs and improved downstream. This condition is due primarily to the high levels of calcium, sulfate, and metallic ions in the discharge from the Anaconda Company settling ponds which precipitate as gypsum and insoluble metallic hydroxides and coat the bottom. Reduction in the concentrations of these constituents, both due to precipitation and tributary dilutions, results in a gradual improvement downstream.

B. Seasonal Differences

The seasonal high flow in the Clark Fork River is about four times greater than the low flow. To evaluate the influence of flow levels on water quality, the data were separated and averaged according

to flow period as shown in Table VI. Analysis of the data shows the concentrations of hardness, alkalinity, and dissolved metals are lower during high flow period in the spring than during the low flow period in late summer and fall. The values for pH were also lower during the higher flows. Conversely, the concentrations of total iron, total copper, and total zinc are highest during the maximum flow period which indicates an increased concentration of suspended material.

C. Intermittent Waste Discharges

On six occasions water quality conditions indicative of spills were observed. Red water[1/] discharges from the Anaconda settling ponds were documented on October 6 and October 21, 1970. In both instances, the red water was also observed at the Warm Springs station. A yellowish-colored[2/] discharge from the pond was documented on October 22, 1970. On August 11, 1970, red water was observed and documented at Deer Lodge. The water quality for all the mainstem Clark Fork stations and the settling pond effluent on dates of spills are presented in Table VII. Underlined values correspond to stations where red or yellow water was observed.

1/ Red coloration is due to high concentrations of ferric hydroxide. This is one of the waste constituents normally removed by the ponds.

2/ Yellow coloration due to high concentrations of ferrous hydroxide.

TABLE VI

AVERAGE WATER QUALITY CONDITIONS FOR HIGH AND LOW PERIODS

Parameter	Flow Period	CF at Warm Springs		CF at Dempsey		CF at Deer Lodge		CF at Tavenner Ranch Bridge		CF at Garrison		CF at Drummond	
		Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max
pH	H	6.2	(5.9)[1/]	6.3	(6.1)	6.4	(6.0)	6.4	(6.2)	6.3	(5.6)	---	---
	L	7.7	(7.1)	7.7	(6.9)	7.7	(7.1)	7.8	(7.5)	8.0	7.7	8.0	7.7
Total Alkalinity, mg/l as $CaCO_3$	H	41	48	71	95	85	125	104	190	99	150	---	---
	L	50	85	106	137	122	145	134	162	132	142	157	200
Total Hardness, mg/l as $CaCO_3$	H	713	990	520	785	486	724	457	620	472	923	---	---
	L	1270	1430	845	1080	845	1950	679	900	566	720	434	620
Sulfate, mg/l	H	---	---	---	---	---	---	---	---	---	---	---	---
	L	1230	1450	637	800	515	675	547	600	397	420	260	300
Total Copper, ug/l	H	130	220	233	420	408	1200	215	360	113	160	---	---
	L	235	1360	78	160	74	190	108	460	80	240	51	90
Dissolved Copper, ug/l	H	31	50	29	40	47	70	34	60	26	40	---	---
	L	47	70	42	60	39	60	53	190	34	60	36	50
Total Zinc, ug/l	H	420	720	487	960	1210	4700	488	1000	252	340	---	---
	L	1000	4200	256	460	211	500	185	500	133	280	102	160
Dissolved Zinc, ug/l	H	278	580	115	170	127	230	112	220	65	130	---	---
	L	508	1400	178	280	150	240	127	230	93	170	71	140

"H" = High
"L" = Low
1/ ( ) indicates minimum rather than maximums.

TABLE VI (CONTINUED)

AVERAGE WATER QUALITY CONDITIONS FOR HIGH AND LOW PERIODS

Parameter	Flow Period	CF at Warm Springs		CF at Dempsey		CF at Deer Lodge		CF at Tavenner Ranch Bridge		CF at Garrison		CF at Drummond	
		Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max
Total Iron, ug/l	H	1565	2800	3030	6800	5650	18000	3250	7200	3160	8400	---	---
	L	1870	12500	410	1500	424	1800	425	2200	330	1500	288	800
Dissolved Iron, ug/l	H	118	160	156	220	188	320	173	280	138	180	---	---
	L	154	300	176	500	141	300	149	400	153	520	143	300

TABLE VII

WATER QUALITY CHARACTERISTICS DURING SPILLS

Parameter	Date	Settling Pond 3 at Outfall	CF at Warm Springs	CF at Dempsey	CF at Deer Lodge	CF at Tavenner Ranch Bridge	CF at Garrison	CF at Drummond
pH	7/14	---	5.9	6.1	6.2	6.5	6.2	---
	8/11	8.6	7.8	7.7	7.6	7.5	7.8	7.7
	10/6	8.6	7.5	7.7	7.7	7.6	7.8	8.0
	10/7	8.9	7.8	7.8	7.8	8.2	8.2	8.2
	10/21	9.3	7.7	8.0	8.0	8.2	8.0	7.8
	10/22	8.8	7.1	7.9	7.9	8.0	8.3	8.3
Total Copper, mg/l	7/14	---	52	400	1200	205	22	---
	8/11	90	80	60	70	50	70	50
	10/6	1300	380	60	70	460	60	50
	10/7	880	130	100	80	80	70	60
	10/21	19500	1360	80	70	50	70	70
	10/22	220	160	70	30	40	30	40
Dissolved Copper, mg/l	7/14	---	---	---	---	---	---	---
	8/11	60	40	40	40	40	30	40
	10/6	50	70	60	50	190	60	40
	10/7	50	40	40	30	40	20	40
	10/21	---	60	40	20	30	40	40
	10/22	40	40	30	20	170	30	30
Total Zinc, mg/l	7/14	---	280	960	4700	440	30	---
	8/11	80	400	110	70	60	40	40
	10/6	4600	1500	210	180	240	140	90
	10/7	2800	440	280	---	140	120	100
	10/21	67500	4200	310	170	160	130	140
	10/22	660	1800	340	160	170	90	80

TABLE VII (CONTINUED)

WATER QUALITY CHARACTERISTICS DURING SPILLS

Parameter	Date	Settling Pond 3 at Outfall	CF at Warm Springs	CF at Dempsey	CF at Deer Lodge	CF at Tavenner Ranch Bridge	CF at Garrison	CF at Drummond
Dissolved Zinc, mg/l	7/14	---	280	110	110	90	30	---
	8/11	80	240	70	60	40	30	20
	10/6	100	560	200	---	---	---	---
	10/7	360	320	280	---	140	100	90
	10/21	67500	880	210	140	160	130	110
	10/22	50	1400	240	150	140	90	40
Total Iron, mg/l	7/14	---	450	4250	18000	2100	200	---
	8/11	120	160	---	60	140	---	80
	10/6	21000	3200	350	500	400	400	350
	10/7	14000	600	400	300	200	200	300
	10/21	300000	12500	400	200	200	175	300
	10/22	3100	1650	520	250	200	150	150
Dissolved Iron, mg/l	7/14	---	160	180	320	280	---	---
	8/11	120	160	---	200	100	60	40
	10/6	300	300	300	300	400	150	300
	10/7	600	250	400	100	100	150	200
	10/21	263000	125	125	100	175	175	300
	10/22	125	125	100	75	75	150	50

II. Biological Quality

A. Benthic

Table VIII presents a summary of benthic data for the eight biological sampling stations. The first number listed for each station indicates the total number of organisms per square foot of bottom area assuming two square feet for basket samplers and one square foot for each Surber. (Preliminary field studies showed the organisms collected in two Surbers to be equal in number to organisms collected in one basket.) The next three numbers relate to the variety of taxa observed at each station is self explanatory. The average number of taxa per square foot was calculated by dividing the total number of taxa found at each station by the total number of square feet from which they were collected. The percent occurrence of taxa was calculated by dividing the total number of different taxa found throughout the study area into the total number of different taxa collected at each station. The last column in the Table is a diversity index calculated using the following formula:

$$\text{Index Number} = \frac{S-1}{\text{Log } N}$$

where S = number of taxa
N = number of individuals

The detailed biological data for each station is presented in Appendix C.

For the stations on the Clark Fork River, the data in Table VIII indicate an improvement in water quality with increasing distance downstream from the Warm Springs station; for example, between Warm Springs and Garrison, Montana, the diversity index increased about one hundred-forty-five percent and the average number of taxa increased five hundred percent.

TABLE VIII

AQUATIC ORGANISMS SUMMARY PROFILE
UPPER CLARK FORK RIVER

SUMMER - 1970

Station Storet No. River Mile	Average Number /sq.ft.	Total Number Taxa	Average Number Taxa/sq.ft.	Taxa Percent Occurrence	Diversity Index
Warm Springs 293030 483.7	8	66	1.1	15	5.5
Dempsey Bridge 293031 470.6	897	1919	4.3	49	6.1
Deer Lodge 293007 461.2	715	20	4.5	51	6.6
W-T Bridge 293032 453.8	639	24	5.3	62	8.2
Garrison (Pat's) 293027 444.5	342	21	5.5	54	7.9 8.6
Willow Cr. (I-90) 293027 490.6	80	19	4.3	49	9 9.5
Warm Springs Creek 293029 483.5	96	21	4.3	54	10 10
Little Blackfoot River (I-90) 293033 446.2	176	27	6.7	69	11.6

The data for the average number of organisms/ft^2 in the Clark Fork River shows a significant increase between Warm Springs and Dempsey, Montana. Below Dempsey, Montana, the number of total organisms gradually decrease until at Garrison, Montana, there are less than half of the numbers found at Dempsey. Examination of Appendix C shows that one or two pollution tolerant forms constitute most of the total number of organisms at Dempsey indicating that water quality is impaired to the point where less tolerant organisms are inhibited. The availability of carbon and nutrient material to support growth is also increased due to the effluent from the state hospital lagoon at Warm Springs, Montana. The Clark Fork River water quality progressively improves downstream and the pollution sensitive forms increase in occurrence and number (see Appendix C). The biological conditions at the Garrison, Montana, station are generally representative of a well-balanced system with significant numbers of many taxa being present.

The quality of the benthic community in the tributaries was consistently high. The Little Blackfoot River supported the most diverse population, but all the tributaries sampled had more diverse populations than any of the Clark Fork River stations. This is consistent with the higher water quality measured in the tributaries (Table V).

B. Fish

The 1969-1970 fish population studies conducted on the Clark Fork River by the Montana Fish and Game Department show significant variations

in numbers for various reaches. A copy of the April 1969 - March 1970 report of these studies is included as Appendix D. In a 2.2 mile reach of the Clark Fork River near Warm Springs, Montana, (Figure 1), no fish were found. In the Clark Fork River near Dempsey, Montana, populations increased; however, fish were not found in many of the habitat niches which would usually be occupied. In the reach of the Clark Fork River, between Deer Lodge and Garrison, Montana, a further improvement in fish populations was noted, and a sustaining fish population exists in the Clark Fork River around Drummond, Montana. There is also an active sport fishery in this portion of the stream. This assessment is further verified by comments in a letter to the Environmental Protection Agency from the Montana Fish and Game Department (Appendix E).

Originally, another fish population study of the Clark Fork River was planned for the fall of 1970. After the first study however, Fish and Game Department biologists indicated that the data obtained, supported by creel census data, adequately defined the condition of the upper mainstem fish populations. Therefore, the 1970 fish sampling efforts were concentrated on the tributaries.

With the exception of Willow Creek, all the tributary stations sampled supported larger and healthier game fish populations than those found in the upper reaches of the mainstem study area. A shocking survey of Lost Creek revealed a good, naturally reproducing brown trout population. Warm Springs Creek in Powell County also had a large population of game fish (see Appendix D-2).

DISCUSSION

I. Comparison of Existing Conditions With Standards

The first step toward developing changes in, or recommending additions to, existing water quality standards is to compare present quality in the area of interest with the quality required to meet the designated beneficial uses. In the following discussions the results of the field evaluations are compared with the water quality standards classification and designated beneficial uses for each reach of the Clark Fork River.

A. Silver Bow Creek

Silver Bow Creek is the officially designated extension of the Clark Fork River. The Montana Water Quality Standards classify Silver Bow Creek from the confluence of Yankee Doodle and Blacktail Deer Creeks to the mouth of Warm Springs Creek for industrial water use. At the present time that is the sole use of this reach. The Anaconda Copper Company has almost a total water right on the stream and uses it to transport wastes from Butte to the settling ponds at Anaconda. The Company is to remove these wastes from Silver Bow Creek by July, 1972, at which time additional studies are warrented to establish new, achievable beneficial uses.

B. Clark Fork River From Warm Springs Creek to the Mouth of the Little Blackfoot River

Of the beneficial uses designated for this reach, the growth and marginal propagation of salmonid fish and associated aquatic life is the one which determines most of the quality criteria with the

criteria for toxic or other deleterious substances and pH being most important.

Previous discussions indicate that in the reach of the Clark Fork River between the mouth of Warm Springs Creek and Deer Lodge, Montana, the stream is biologically and chemically degraded. There is almost a total lack of benthic biota at Warm Springs, Montana, and the numbers and diversity of organisms at Dempsey and Deer Lodge, Montana, are still not indicative of a healthy system. The fish population studies indicate that no significant game fish population exists in this reach of the river.

The degraded water quality conditions in Warm Springs Creek and Deer Lodge reach are due to a combination of several factors. The precipitation of gypsum and metallic hydroxides eliminates or greatly reduces the availability of bottom gravels for fish spawning and benthic habitat. Individually, the average concentrations of dissolved metals, hardness, pH, etc., are probably not high enough to cause acute toxicity; but, synergistically, they cause a very significant stress on the biological population. This stress is magnified by the higher concentrations found during spills. The overall adverse impact on the biota is evident.

From Deer Lodge, Montana, to the mouth of the Little Blackfoot River, water quality conditions in the Clark Fork River are improved. No significant bottom cementing occurs and populations of bottom organisms show a greater diversity and are generally indicative of a healthy benthic biota. Game fish increase in number, and between the Tavenner Ranch and Garrison, Montana, a limited sport fishery exists.

Based on the results of this survey, the water quality of the Clark Fork River above Deer Lodge, Montana, does not support the growth and marginal propagation of salmonid fish as required by the C-D_2 water quality standards classification and the criteria relating to "toxic or deleterious substances" is being violated. Below Deer Lodge, Montana, particularly in that portion of the stream between the Tavenner Ranch and Garrison, Montana, the results indicate that the Clark Fork River supports growth and marginal propagation of salmonids. Since the uses associated with the C-D_2 classification are being supported by the existing water quality at Garrison, Montana, the average concentration of heavy metals measured at Garrison are recommended as the criteria for the C-D_2 classification of the Montana Water Quality Standards. However, since there are seasonal variations and since the survey indicates that the water quality at Deer Lodge, Montana, also appears to support the designated beneficial uses, it is recommended that the average heavy metals concentrations measured at Deer Lodge, Montana, be adopted as the maximum allowable instantaneous peak concentrations for the C-D_2 classification.

C. Clark Fork River Below the Mouth of the Little Blackfoot River

Of the beneficial uses designated for this reach, the most pertinent to this study is the growth and propagation of salmonid fish. Where this designated use is supported by the water quality, the criterion relating to toxic substances can be numerically established.

Conditions improve rapidly in the reach from the mouth of the Little Blackfoot River to Drummond, Montana, the lower limit of the study

area. There is a diverse, well-balanced community of benthic biota just downstream of Garrison, Montana. Water quality improves progressively downstream and at Drummond, Montana, approaches tributary quality. The Clark Fork River in the vicinity of Drummond, Montana, is considered to be one of the better sport fishing streams in Montana. Therefore, the uses associated with the B-D_1 classification are being supported by the existing water quality at Drummond, Montana, and the average heavy metals concentrations measured at the Drummond, Montana, station are recommended as the criteria for the B-D_1 classification of the Montana Water Quality Standards. Also, in recognition of seasonal variations and the fact that the B-D_1 classification appears to be supported by the water quality at Garrison, Montana, it is recommended that the average heavy metals concentrations measured at Garrison, Montana, be adopted as the maximum allowable instantaneous peak concentrations for the B-D_1 classification.

APPENDIX A

COPY OF STUDY REQUEST
FROM
STATE OF MONTANA

A-1

State of Montana

State Department of Health

JOHN S. ANDERSON, M.D.
EXECUTIVE OFFICER

HELENA, MONTANA 59601

March 17, 1970

Mr. James Agee, Regional Director
Federal Water Pollution Control Administration
Room 501, Pittock Block
Portland, Oregon 97205

Dear Mr. Agee:

Mr. D. G. Willems of the Department of Health water pollution control staff has had several discussions with members of your staff regarding the need for field work in the Butte-Anaconda area. This work cannot be accomplished by our staff because of our small budget. We feel the following work is needed:

1. Bioassays or stream studies to determine the maximum limits for heavy metals in the Clark Fork River.

2. A study to determine the probable water quality effects of storm runoff in the Butte area, the effects of groundwater discharge on surface water quality, and the probable water quality of Silver Bow Creek if the mine-mill wastes are diverted from it.

This information is needed before the design of additional treatment facilities is started by the Anaconda Company, and we sincerely seek the help of the Federal Water Pollution Control Administration in obtaining the needed information as soon as possible.

Sincerely yours,

John S. Anderson

John S. Anderson, M.D.
Executive Officer

JSA:DGW:sdd

APPENDIX B

INFORMATION ON SAMPLING AND ANALYTICAL METHODS

SAMPLE HANDLING AND ANALYTICAL PROCEDURES

I. Sample Handling

A. Collection

At each river sampling station, three clean plastic containers were filled (two, one-liter samples and one 500 milliliter sample). At all stations this was accomplished by hand from shore. The containers were filled directly from the river and sampling equipment was not used. At Station 293036 the samples were taken directly from the decant tower.

B. Documentation

All sample containers were tagged at the time of filling. The information recorded on the tags included project, date, time, station, laboratory identification number, preservation, and depth (where appropriate). The same information was recorded in a field book, along with any observations and the results of the field analyses. The field notes are presently located in the project files of the Technical Assistance and Investigations Branch, Office of Technical Programs, Water Quality Office, Environmental Protection Agency.

At the conclusion of the field survey, samples for laboratory analyses were transported to the Pacific Northwest Laboratory by survey personnel. At the laboratory the samples were logged in and then held in a sample storage room until the analyses were performed.

C. Preservation

Preservation methods depend upon the analyses to be performed. The laboratory analyses required for these samples were total hardness and total and dissolved concentrations of zinc, iron, lead, and copper.

The samples for total hardness did not require preservation. Those for metals analyses were preserved by adding 25 milliliters of concentrated nitric acid (HNO_3) per liter of sample. In the case of the samples for dissolved metals, the samples were filtered through a 0.45 micron membrane filter prior to addition of the acid preservative. This filter size has been established as the dividing line between dissolved and particulate metals. The preservation measures used for these samples were specified by the Chief Chemist, Consolidated Laboratory Services, Pacific Northwest Water Laboratory (PNWL), located in Corvallis, Oregon.

II. Analytical Procedures

A. Field Analyses

Field determinations were made on all samples for the following parameters: temperature, pH, alkalinity, and conductivity. The analytical procedures used for these procedures are outlined below. If a standard method was used, only the appropriate reference is cited.

1. Temperature. Either bucket or in situ temperatures were taken with a standard mercury laboratory thermometer.

2. pH. The pH determinations were made using a Beckman Electromate (Beckman Instruments, Inc.). Frequent checks on the calibration were made using standard buffer solutions.

3. Alkalinity. The alkalinity analyses were conducted according to the method specified in the 12th Edition, Standard Methods for the Examination of Water and Wastewater, 1965. The endpoint for the titration was determined with a pH meter. Distilled water for dilution was transported from the laboratory.

4. Conductivity. Conductivity determinations were made using a Beckman Model RB-3-327 Conductivity Meter.

B. Laboratory Analyses

The analyses conducted at the laboratory were total hardness, total and dissolved metals. The methods used for these analyses are outlined below:

1. Total Hardness. Hardness analyses were made using the EDTA titration method specified in the 12th Edition of Standarrd Methods.

2. Metals. All metals analyses were conducted using the atomic absorption methods outlined in FWPA Methods for Chemical Analysis of Water and Wastes--November 1969. Where conductivity indicated low concentrations of dissolved constituents, the samples were concentrated by evaporation prior to analysis.

TABLE B-1

DESCRIPTION OF SAMPLING STATIONS

Description	Latitude-Longitude	Storet Station No.
Clark Fork River at bridge in Drummond, MT.	Lat. 46° 39' 42" Long. 113° 08' 54"	293023
Clark Fork River-behind tavern approximately one mile downstream from Garrison, MT.-sample near irrigation pump.	Lat. 46° 52' 38" Long. 113° 55' 53"	293006
Clark Fork River at Williams and Tavenner Ranch cutoff from Frontage Road below Deer Lodge-sample downstream from bridge	Lat. 46° 28' 25" Long. 112° 43' 40"	293032
Clark Fork River at Deer Lodge-sample just above Milwaukie Avenue bridge	Lat. 46° 52' 38" Long. 113° 55' 53"	293007
Clark Fork River at Dempsey Creek Bridge just above old mouth of Dempsey Creek	Lat. 46° 18' 55" Long. 112° 44' 06"	293031
Clark Fork River-approximately 1/4 mile above mouth of Warm Springs Creek	Lat. 46° 11' 12" Long. 112° 46' 12"	293030
Outfall of Anaconda Copper Co. settling pond #3-sample from center decant tower	Lat. 46° 11' Long. 112° 46'	293036
Flint Creek-at bridge on county road to New Chicago, Montana approximately two miles above mouth-sample upstream	Lat. 46° 37' 43" Long. 113° 09' 54"	293034
Gold Creek, about 1.5 miles south of Gold Creek, Montana at point where creek crosses road-sample on upstream side.	Lat. 46° 33' 45" Long. 112° 55' 34"	293022
Brock Creek at I-90 (U.S.-10)-sample on river side.	Lat. 46° 33' 20" Long. 112° 52' 00"	293040
Warm Springs Creek below Garrison at I-90 (U.S.-10) bridge-sample downstream	Lat. 46° 32' 25" Long. 112° 50' 40"	293039
Little Blackfoot River at I-90 (U.S.-10) bridge-sample downstream	Lat. 46° 31' 10" Long. 112° 47' 32"	293033
Racetrack Creek at I=90 (U.S.-10)-sample between highway and railroad	Lat. 46° 15' 57" Long. 112° 44' 58"	293041
Lost Creek at I-90 (U.S.-10)-sample downstream side	Lat. 46° 13' 08" Long. 112° 46' 25"	293042

TABLE B-1 (Continued)

Description	Latitude-Longitude	Storet Station No.
Warm Springs Creek-approximately 1/4 mile above mouth of creek	Lat. 46° 11' 10" Long. 112°46' 18"	293029
Warm Springs Creek at bridge just above Anaconda, Montana. Approximately 0.5 mile upstream from Fish Hatchery-sample upstream side.	Lat. 46° 08' 32" Long. 112° 59' 00"	293025
Silver Bow Creek - just above bridge where it crosses I-90 (U.S.-10) bridge.	Lat. 46° 06' 33" Long. 112° 48' 00"	293028
Silver Bow Creek (Clark Fork River at Ramsey - sample below railroad bridge.	Lat. 46° 00' 00" Long. 112° 41' 30"	293035
Willow Creek-just above I-90 (U.S.-10) bridge.	Lat. 46° 06' 41" Long. 112° 48' 00"	293027
Mill Creek-just above I-90 (U.S.-10) bridge. (Drain from tailing pond)	Lat. 46° 06' 53" Long. 112° 48' 00"	293026

TABLE B-2

WATER QUALITY SAMPLING DATES FOR EACH STATION

STATION	STORET STATION NO.	MAY 18 & 20	JUNE 29 & 30	JULY 14 & 15	AUGUST 11 & 13	AUGUST 26 & 27	SEPTEMBER 15 & 17	OCTOBER 6 & 7	OCTOBER 21 & 22	NOVEMBER 3 & 4
Clark Fork at Drummond	293023	X			X		X	X	X	X
Clark Fork Below Garrison	293006	X	X	X	X	X	X	X	X	X
Clark Fork at Williams & Tavennar Ranch Bridge	293032	X	X	X	X	X	X	X	X	X
Clark Fork at Deer Lodge	293007	X	X	X	X	X	X	X	X	X
Clark Fork at Dempsey	293031	X	X	X	X	X	X	X	X	X
Clark Fork at Warm Springs	293030	X	X	X	X	X	X	X	X	X
Outfall of Anaconda Company Settling Pond No. 3	293036				X			X	X	X
Flint Creek	293034	X			X		X	X	X	X
Gold Creek	293022	X			X		X	X	X	X
Brock Creek	293040				X		X	X	X	X
Warm Springs Creek (Powell County)	293039				X		X	X	X	X
Little Blackfoot River	293033	X	X	X	X	X	X	X	X	X
Racetrack Creek								X	X	X
Lost Creek								X	X	X
Warm Springs Creek (Deer Lodge County) near mouth	293029	X	X	X	X	X	X	X	X	X
Warm Springs Creek (Deer Lodge County) above Anaconda	293025	X			X					
Silver Bow Creek at I-90 Bridge	293028	X	X	X	X	X	X	X	X	X
Silver Bow Creek at Ramsey	293035	X	X	X	X	X	X	X	X	X
Willow Creek at I-90	293027	X	X	X	X	X	X	X	X	X
Mill Creek at I-90	293026	X	X	X	X	X	X	X	X	X
Dempsey Creek	293037				X		X			

APPENDIX C

DETAILED DATA ON BENTHIC BIOTA

APPENDIX C

BIOLOGICAL DATA

Stations	Date	Sampler	Organisms Common Name	Family	Stage	Number	No. Forms Total No.
pH Shack	6/29/70	Basket	0	0	0	0	
STORET #293030	8/12/70	Basket	True Flies	Tendipedidae	Larvae	17	
				Simuliidae	Pupae	1	
				Roundworms	Adult	1	
		Surber (4)	Caddisflies	Hydropsychidae	Larvae	7	
			True Flies	Tendipedidae	Larvae	22	
					Pupae	4	
				Rhagionidae	Larvae	1	
				Simuliidae	Larvae	10	
					Pupae	2	
	9/16/70	Basket	Stone Flies	Pteronarcidae	Nymph	1	
			Caddisflies	Hydroptilidae		1	
			True Flies	Tendipedidae	Larvae	1	
					Pupae	1	
				Simuliidae	Larvae	6	
Dempsey Cr. Bridge #293031	6/29/70	Basket	Caddisflies	Brachycentridae	Larvae	5	
				Hydropsychidae	Larvae	119	
			True Flies	Orthocladiidae	Larvae	1	
				Tendipedidae	Larvae	3	
	8/12/70	Basket	Caddisflies	Brachycentridae	Larvae	14	
					Pupae	12	
				Hydropsychidae	Larvae	788	
					Pupae	10	
				Hydroptilidae	Larvae	58	
					Pupae	28	
			True Flies	Tendipedidae	Larvae	251	
					Pupae	47	
				Rhagionidae	Larvae	19	
				Simuliidae	Larvae	115	
					Pupae	82	
				Tipulidae	Larvae	2	
			Beetles	Dytiscidae	Larvae	2	
				Cyrinidae	Larvae	2	
			Side Swimmer	Talitridae	Adult	1	
			Earthworm		Adult	5	
			Roundworm		Adult	2	
			Water Mite		Adult	7	
		Surber	Caddisflies	Brachycentridae	Larvae	23	
					Pupae	100	
				Hydropsychidae	Larvae	145	
					Pupae	25	
				Hydroptilidae	Larvae	71	
					Pupae	104	

APPENDIX C

BIOLOGICAL DATA

(Continued)

Station	Date	Sampler	Organisms				No. Forms
			Common Name	Family	Stage	Number	Total No.
Dempsey Creek Bridge #293031 (Continued)	8/12/70 (Cont'd)	Surber (Cont'd)	May Flies	Baetidae	Nymph	1	
			True Flies	Tendipedidae	Larvae	743	
					Pupae	319	
				Empididae	Pupae	9	
				Rhagionidae	Larvae	108	
				Simuliidae	Larvae	11	
					Pupae	10	
				Tipulidae	Larvae	6	
					Pupae	1	
			Beetles	Dytiscidae	Larvae	4	
				Elmidae	Larvae	2	
			Side Swimmers	Talitridae	Adult	1	
			Earthworm		Adult	1	
			Water Mite		Adult	32	
	9/16/70	Basket	Caddisflies	Brachycentridae	Larvae	108	
					Pupae	4	
				Hydropsychidae	Larvae	2336	
				Hydroptilidae	Larvae	56	
					Pupae	8	
				Leptoceridae	Larvae	8	
			True Flies	Tendipedidae	Larvae	404	
					Pupae	20	
				Rhagionidae	Larvae	68	
				Simuliidae	Larvae	1220	
					Pupae	1416	
				Tipulidae	Larvae	12	
			Beetles	Elmidae	Larvae	12	
			Earthworm		Adult	4	
			Water Mite		Adult	12	
			Roundworm		Adult	8	
Deer Lodge #293007	6/29/70	Basket	Caddisflies	Brachycentridae	Larvae	14	
					Pupae	1	
				Hydropsychidae	Larvae	192	
					Pupae	10	
				Hydroptilidae	Larvae	1	
					Pupae	4	
				Leptoceridae	Larvae	3	
				Rhyacophilidae	Pupae	1	
			True Flies	Tendipedidae	Larvae	8	
				Empididae	Larvae	1	
	8/12/70	Basket	Caddisflies	Brachycentridae	Larvae	6	
					Pupae	37	
				Hydropsychidae	Larvae	168	
					Pupae	2	
				Hydroptilidae	Larvae	616	
					Pupae	768	
			Stone Flies	Pteronarcidae	Nymph	8	
			True Flies	Tendipedidae	Larvae	880	
					Pupae	168	
				Rhagionidae	Larvae	40	
				Tipulidae	Larvae	8	
					Pupae	4	

APPENDIX C

BIOLOGICAL DATA

(Continued)

Station	Date	Sampler	Organisms				No. Forms
			Common Name	Family	Stage	Number	Total No.
Deer Lodge #293007 (Continued)	8/12/70	Basket	Earthworm		Adult	76	
			Water Mite		Adult	28	
			Roundworm		Adult	4	
		Surber	Caddisflies	Brachycentridae	Larvae	1	
					Pupae	14	
				Hydropsychidae	Larvae	137	
					Pupae	7	
				Hydroptilidae	Larvae	184	
					Pupae	407	
			True Flies	Tendipedidae	Larvae	968	
					Pupae	418	
				Empididae	Larvae	1	
					Pupae	2	
				Rhagionidae	Larvae	77	
				Simuliidae	Larvae	17	
					Pupae	4	
				Tipulidae	Larvae	23	
					Pupae	2	
			Stone Flies	Pteronarcidae	Nymph	1	
			Beetles	Dytiscidae	Larvae	3	
				Elmidae	Larvae	2	
			Earthworm		Adult	8	
			Water Mite		Adult	25	
			Springtail		Adult	1	
			Roundworm		Adult	7	
	9/16/70	Basket	Caddisflies	Brachycentridae	Larvae	6	
					Pupae	5	
				Hydropsychidae	Larvae	174	
				Hydroptilidae	Larvae	2	
					Pupae	42	
				Leptoceridae	Larvae	17	
			True Flies	Tendipedidae	Larvae	764	
					Pupae	107	
				Rhagionidae	Larvae	90	
				Simuliidae	Larvae	20	
					Pupae	1	
			Stone Flies	Pteronarcidae	Nymph	1	
			May Flies	Baetidae	Nymph	3	
			Dragonflies	Aeshnidae	Nymph	1	
			Seed Shrimp		Adult	1	
			Earthworm		Adult	543	
			Water Mite		Adult	1	
W-T Bridge #293032	8/12/70	Basket	Caddisflies	Hydropsychidae	Larvae	47	
				Hydroptilidae	Larvae	298	
					Pupae	7	
				Limnephilidae	Larvae	17	
			Stone Flies	Pteronarcidae	Nymph	1	
			True Flies	Tendipedidae	Larvae	52	
					Pupae	7	
				Tipulidae	Larvae	6	
			Beetles	Dytiscidae	Larvae	2	

APPENDIX C

BIOLOGICAL DATA

(Continued)

Stations	Date	Sampler	Organisms			
			Common Name	Family	Stage	Number
W-T Bridge #293032	8/12/70	Basket	Earthworm		Adult	50
			Water Mite		Adult	2
			Roundworm		Adult	1
(Continued)			Jellyfish	Hydridae	Adult	21
		Surber	Caddisflies	Helicopsychidae	Pupae	1
				Hydropsychidae	Larvae	1438
					Pupae	1
				Hydroptilidae	Larvae	629
					Pupae	475
			Stone Flies	Chloroperlidae	Nymph	2
			May Flies	Baetidae	Nymph	9
				Heptageniidae	Nymph	1
			True Flies	Tendipedidae	Larvae	437
					Pupae	174
				Empididae	Larvae	2
				Rhagionidae	Larvae	7
				Simuliidae	Larvae	7
					Pupae	5
				Tipulidae	Larvae	8
					Pupae	1
			Beetles	Dytiscidae	Larvae	11
			Side Swimmer	Talitridae	Adult	6
			Water Mite		Adult	119
			Earthworm		Adult	2
			Roundworm		Adult	2
	9/16/70	Basket	Caddisflies	Brachycentridae	Larvae	4
				Helicopsychidae	Larvae	6
				Hydropsychidae	Larvae	861
				Hydroptilidae	Pupae	10
				Rhyacophilidae	Larvae	1
			Stone Flies	Perlodidae	Nymph	1
				Pteronarcidae	Nymph	1
			True Flies	Tendipedidae	Larvae	368
					Pupae	26
				Simuliidae	Larvae	12
					Pupae	3
				Tipulidae	Larvae	3
			Water Fleas		Adult	2
			Earthworm		Adult	9
			Snail	Physidae	Adult	5
			Moss Animals		Adult	1
			Water Mite		Adult	5
			Roundworm		Adult	10
Garrison (Pat's) #293006	6/29/70	Basket	Caddisflies	Brachycentridae	Larvae	21
				Helicopsychidae	Larvae	3
				Hydropsychidae	Larvae	113
					Pupae	134
				Hydroptilidae	Larvae	3
				Lepidostomatidae	Larvae	4
					Pupae	76
				Leptoceridae	Larvae	1

APPENDIX C

BIOLOGICAL DATA

(Continued)

Station	Date	Sampler	Organisms			
			Common Name	Family	Stage	Number
Garrison (Pat's) #293006 (Continued)	6/29/70	Basket	Stone Flies	Pteronarcidae	Nymph	4
				Chloroperlidae	Nymph	1
				Perlodidae	Nymph	3
			May Flies	Baetidae	Nymph	2
				Ephemerellidae	Nymph	10
			True Flies	Orthocladiidae	Larvae	6
				Tendipedidae	Larvae	3
				Empididae	larvae	1
			Beetles	Dytiscidae	Larvae	1
				Elmidae	Larvae	1
	8/12/70	Basket	Caddisflies	Brachycentridae	Larvae	2
					Pupae	13
				Helicopsychidae	Larvae	1
				Hydropsychidae	Larvae	1391
				Hydroptilidae	Larvae	452
					Pupae	76
				Leptoceridae	Larvae	1
			Stone Flies	Pteronarcidae	Nymph	23
			May Flies	Baetidae	Nymph	8
				Ephemerellidae	Nymph	1
			True Flies	Tendipedidae	Larvae	193
					Pupae	19
				Rhagionidae	Larvae	4
				Simuliidae	Larvae	9
					Pupae	4
				Tipulidae	Larvae	5
			Beetles	Elmidae	Larvae	28
			Earthworms		Adult	5
			Water Mites		Adult	1
			Jellyfish	Hydridae	Adult	1
		Surber	Caddisflies	Hydropsychidae	Nymph	239
				Hydroptilidae	Nymph	20
					Pupae	7
			May Flies	Baetidae	Nymph	8
				Ephemerellidae	Nymph	1
			True Flies	Tendipedidae	Larvae	103
					Pupae	24
				Rhagionidae	Larvae	2
				Simuliidae	Larvae	1
				Tipulidae	Larvae	9
					Pupae	2
			Beetles	Elmidae	Larvae	6
			Earthworms		Adult	4
			Water Mites		Adult	3
			Roundworm		Adult	4
			Jellyfish	Hydridae	Adult	2
	9/16/70	Basket	Caddisflies	Brachycentridae	Larvae	2
				Hydropsychidae	Larvae	340
				Hydroptilidae	Larvae	4
					Pupae	23
				Leptoceridae	Larvae	1

APPENDIX C

BIOLOGICAL DATA

(Continued)

Stations	Date	Sampler	Organisms			
			Common Name	Family	Stage	Number
Garrison (Pat's) #293006 (Continued)	9/16/70	Basket	Stone Flies	Pteronarcidae	Nymph	31
			True Flies	Tendipedidae	Larvae	32
					Pupae	7
				Simuliidae	Larvae	10
					Pupae	2
				Tipulidae	Larvae	1
			Beetles	Elmidae	Larvae	5
			Earthworm		Adult	3
Willow Creek #293027	6/29/70	Basket	Caddisflies	Brachycentridae	Nymph	2
				Hydropsychidae	Nymph	12
					Pupae	1
				Lepidostomatidae	Nymph	4
					Pupae	5
				Rhyacophilidae	Pupae	1
			Stone Flies	Pteronarcidae	Nymph	8
				Perlidae	Nymph	2
				Perlodidae	Nymph	1
			May Flies	Baetidae	Nymph	2
				Ephemerellidae	Nymph	6
				Heptageniidae	Nymph	2
			True Flies	Tipulidae	Larvae	4
	8/12/70	Surber	Caddisflies	Brachycentridae	Pupae	1
				Glossosomatidae	Larvae	4
					Pupae	7
				Hydropsychidae	Larvae	54
				Hydroptilidae	Pupae	2
				Limnephilidae	Larvae	3
					Pupae	4
			Stone Flies	Perlodidae	Nymph	7
				Pteronarcidae	Nymph	9
			May Flies	Baetidae	Nymph	115
				Ephemerellidae	Nymph	24
				Heptageniidae	Nymph	5
			True Flies	Tendipedidae	Larvae	63
					Pupae	7
				Simuliidae	Larvae	122
					Pupae	12
			Beetles	Elmidae	Larvae	2
			Earthworm		Adult	2
			Roundworm		Adult	4
Warm Springs #293029	6/29/70	Basket	Caddisflies	Brachycentridae	Nymph	1
				Hydropsychidae	Nymph	15
					Pupae	21
				Limnephilidae	Nymph	2
				Rhyacophilidae	Pupae	1
			Stone Flies	Perlodidae	Nymph	7
			True Flies	Tendipedidae	Larvae	2
				Rhagionidae	Larvae	1
				Tipulidae	Larvae	1
			May Flies	Ephemerellidae	Nymph	6

APPENDIX C

BIOLOGICAL DATA

(Continued)

Stations	Date	Sampler	Common Name	Conclusions		
				Family	Stage	Number
Warm Springs #293029 (Continued)	8/12/70	Basket	Caddisflies	Brachycentridae	Nymph	2
			Stone Flies	Pteronarcidae	Nymph	5
			May Flies	Baetidae	Nymph	1
			True Flies	Tendipedidae	Larvae	18
					Pupae	4
				Tipulidae	Larvae	1
			Spongue Flies	Sialidae	Larvae	3
			Earthworm		Adult	1
			Snail		Adult	1
		Surber	Caddisflies	Hydropsychidae	Nymph	34
				Hydroptiladae	Nymph	53
					Pupae	75
				Limnephilidae	Nymph	1
			Stone Flies	Pteronarcidae	Nymph	43
			May Flies	Baetidae	Nymph	2
				Ephemerellidae	Nymph	9
			True Flies	Tendipedidae	Larvae	259
					Pupae	14
				Rhagionidae	Larvae	2
				Tipulidae	Larvae	22
			Beetles	Dytiscidae	Larvae	72
				Elmidae	Larvae	5
			Side Swimmers	Talitridae		1
			Earthworm		Adult	13
			Roundworm		Adult	4
	9/16/70	Basket	Caddisflies	Hydropsychidae	Nymph	5
				Hydroptilidae	Nymph	19
				Rhyacophilidae	Nymph	8
			May Flies	Baetidae	Nymph	1
				Ephemerellidae	Nymph	1
			True Flies	Tendipedidae	Larvae	53
					Pupae	1
				Simuliidae	Pupae	1
			Dragonflies	Aeshnidae	Nymph	3
			Earthworm		Adult	146
			Snails		Adult	3
			Jellyfish	Hydridae	Adult	11
			Moss Animals		Adult	1
Little Blackfoot River #293033	6/29/70	Basket	Caddisflies	Brachycentridae	Nymph	8
				Hydropsychidae	Nymph	22
				Lepidostomatidae	Nymph	20
					Pupae	3
				Rhyacophilidae	Pupae	1
			Stone Flies	Pteronarcidae	Nymph	2
				Chloroperlidae	Nymph	1
				Perlidae	Nymph	1
				Perlodidae	Nymph	5
			May Flies	Baetidae	Nymph	17
				Ephemerellidae	Nymph	21
				Leptophlebiidae	Nymph	3
			True Flies	Tendipedidae	Larvae	2
				Orthocladiidae	Larvae	2
			Beetles	Elmidae	Larvae	2

APPENDIX C

BIOLOGICAL DATA

(Continued)

Stations	Date	Sampler	Common Name	Conclusions		
				Family	Stage	Number
Little Blackfoot River #293033	8/12/70	Surber	Caddisflies	Brachycentridae	Numph	3
					Pupae	6
				Glossosomatidae	Nymph	3
					Pupae	2
				Helicopsychidae	Pupae	1
(Continued)				Hydropsychidae	Larvae	135
					Pupae	2
				Hydroptilidae	Larvae	1
					Pupae	1
			Stone Flies	Chloroperlidae	Nymph	8
				Perlidae	Nymph	3
				Perlodidae	Nymph	7
				Pteronarcidae	Nymph	1
			May Flies	Baetidae	Nymph	138
				Ephemerellidae	Nymph	18
				Heptageniidae	Nymph	25
			True Flies	Tendipedidae	Larvae	112
					Pupae	10
				Elmidae	Pupae	1
				Simuliidae	Larvae	31
					Pupae	8
				Tipulidae	Larvae	16
					Pupae	1
			Beetles	Elmidae	Larvae	17
			Earthworms		Adult	5
			Roundworms		Adult	1
	9/16/70	Basket	Caddisflies	Brachycentridae	Nymph	65
				Glossosomatidae	Nymph	5
				Hydropsychidae	Nymph	4
				Helicopsychidae	Nymph	58
				Hydroptilidae	Pupae	3
				Lepidostomatidae	Nymph	517
				Leptoceridae	Nymph	30
			Stone Flies	Chloroperlidae	Nymph	13
				Perlidae	Nymph	3
				Perlodidae	Nymph	3
				Pteronarcidae	Nymph	23
			May Flies	Ephemerellidae	Nymph	110
				Heptageniidae	Nymph	10
				Leptophlebiidae	Nymph	27
				Tricorythidae	Nymph	1
			True Flies	Tendipedidae	Larvae	116
					Pupae	5
				Tipulidae	Larvae	2
			Beetles	Elmidae	Larvae	83
			Earthworm		Adult	6
			Clam	Sphaeriidae	Adult	1
			Snail	Physidae	Adult	8

APPENDIX D

MONTANA FISH AND GAME DEPARTMENT
FISHERIES DIVISION

APPENDIX D-1

DATA ON FISH POPULATIONS IN THE
UPPER REACHES OF THE CLARK FORK RIVER
COLLECTED BY THE
MONTANA FISH AND GAME DEPARTMENT

APPENDIX D-1

EXCERPTS FROM THE
MONTANA FISH AND GAME DEPARTMENT
FISHERIES DIVISION

JOB PROGRESS REPORT

State: MONTANA

Project No.: F-12-R-16 Title: Western Montana Fishery Study

Job No.: I-a Title: Inventory of Waters of the Project Area

Period Covered: April 1, 1969 to March 31, 1970

PROCEDURES

Standard methods were used to conduct lake and stream surveys. Standard 125-foot, graduated mesh, nylon grill nets and electrofishing equipment were used to sample fish populations. Survey information was entered on standard Montana Fish and Game Department Lake and Stream survey cards.

Abbreviations for fish species in this report are:

Rb	- rainbow trout, Salmo gairdneri Richardson
Ct	- cutthroat trout, Salmo clarki Richardson
WSCt	- westslope cutthroat trout, Salmo clarki Richardson
DV	- dolly varden, Salvelinus malma Walbaum
Eb	- brook trout, Salvelinus fontinalis Mitchill
Gr	- artic grayling, Thymallus arcticus
LL	- brown trout, Salmo trutta Linnaeus
SS	- coho salmon, Oncorhynchus kisutch Walbaum
KOK	- Kokanee, Oncorhynchus nerka Walbaum
WF	- mountain whitefish, Prosopium williamsoni Girard
F Su	- longnose sucker, Catostomus catostomus Forster
C Su	- largescale sucker, Catostomus macrocheilus Girard
PS	- pumpkinseed, Lepomis gibbosus Linnaeus
SQ	- northern squawfish, Ptychocheilus oregonensis Richardson
RSS	- redside shiner, Richardsonius balteatus Richardson

FINDINGS - STREAMS

CLARK FORK RIVER

Section 2 (05-1456), Section 3 (06-1121), Section 4 (06-1140). Eight (8) different sections of the river were shocked during the report period. All sampling was done to enumerate fish populations in connection with water pollution. Lower sections of the stream both above and below Missoula, but particularly below, are difficult to sample because of the deep, large water volume. Sections sampled and results obtained are given below in ascending order upstream.

Pilot Survey - Gold Creek to Jens - Mark-Recapture Study. Population estimate was made on a 4.3 mile section beginning at the county bridge at the Town of Gold Creek and extending downstream. Numerous whitefish were shocked along with brown trout. However, there were too many whitefish to handle adequately and only brown trout were kept and used in the estimate. One marking and one recapture run were made. Two each brook and cutthroat trout were also caught.

M = 250
C = 281
R = 32

$$N = \frac{(M+1)(C+1)}{(R+1)} = \frac{(251)(282)}{33} = \frac{70782}{33} = 2{,}145$$

$$\text{Variance} = \frac{(\text{pop.est})^2\ (C-R)}{(C+1)\ (R+2)} = \frac{(2145)^2\ (249)}{(282)\ (34)} = \frac{1145655225}{9588} = 119488$$

$$\text{Confidence interval @ 95\% level} = \text{pop.est} \pm 2\ \overline{\text{variance}} = 2145 \pm 2\ \overline{119488}$$

$$= 2145 \pm 2 \times 346$$

$$= 2145 \pm 692$$

	Lower Limit	Point	Upper Limit
C.L. .95	1453	2145	2837

This confidence interval is equal to ± 32%

Estimated number of LL per mile = $\frac{2{,}145}{4.3}$ = 499 or 106 LL per 1,000 feet

Average weight of 255 LL captured on marking run = .71 lbs.

Estimated total weight of LL in section = 1,523 lbs.

The sample of 255 brown trout ranged in length from 5.7 inches to 21.6 inches and averaged 11.7 inches in total length.

Sex determination of brown trout was made using the anal fin as the key characteristic (Grucky and Vladykov, 1968). A total of 492 brown trout were sexed. Thirty two (32) percent were classified as males and 68 percent as females for a ratio of 1 male: 2.1 females.

Follow-up Survey - T8N R9W Sec 4 (SE 1/4). A 400-foot section upstream from the Williams-Tavenner Ranch Bridge at the mouth of Mullan Creek. Shocking was done from the bank and a block net was placed at the lower end of the section, but failed to stay in place due to drifting filamentous algae.

Only one brown trout was caught which was 16.5 inches and 1.54 pounds. One longnose dace was observed.

Follow-up Survey - T8N R9W Sec 4, 9. Clark Fork veterinary clinic to Williams-Tavenner Ranch Bridge, a distance of 1.1 miles. Mark-Recapture Study.

Population estimates were made in the section. Estimates were made on brown trout only for one marking, 1 recapture run; two markings, one recapture run; and 3 markings, one recapture run. One estimate was made for all species combined (whitefish, brown trout, and brook trout) as follows:

1. All species combined (Wf, LL, Eb) - one marking, 1 recapture run:

M = 104 (40 LL, 67 Wf, 2 Eb)
C = 163
R = 9

$$N = \frac{(M+1)(C+1)}{R+1} = 1,722$$

$$\text{Variance} = \frac{(\text{pop est})^2 (C-R)}{(C+1)\ (R+2)}$$

$$\text{C.L.} = \text{Pop est} \pm 2\ \sqrt{\text{variance}}$$

$$= 1722 \pm 2 \times 503 = 1722 \pm 1006$$

$$= 58\%$$

2. LL only (all sizes combined) - one marking, one recapture run:

M = 38
C = 113
R = 7

N = 542

C.L. .95 = 542 ± 348 (±64%)

3. LL only (all sizes combined) - two marking, one recapture run:

M = 38 + 112 = 150
C = 36
R = 9

N = 559

C.L. .95 = 559 ± 288 (±52%)

4. LL only (all sizes combined) - three marking, one recapture run:

M = 38 + 112 + 36 = 186
C = 34
R = 3

N = 1,636

C.L. .95 = 1,636 ± 1,376 (±84%)

Insufficient numbers of marked recaptures (3) were caught in the Item 4 analysis to obtain a very reliable estimate. The best estimate is probably in Item 3 since the most marked recaptures were caught. These estimates probably could have been improved by making one or more additional recapture runs.

The point estimate of 559 brown trout compares with a population of 362 brown trout estimated in August 1967 during the copper strike. Point estimates and confidence limits for the two years are as follows:

Year	Estimate		
	Lower	Point	Upper
1967	256	362	468 (±29%)
1969	271	559	847 (±52%)

The 1967 estimate is more accurate than the 1969 estimate and the confidence limits overlap, indicating no significant difference in population estimates between the two years.

Follow-up Survey - T6N R9W Sec 21 (NW 1/4). A 300-foot section upstream from county road bridge near Race Track.

Shocking was conducted from the bank, a block net was placed across the stream at lower boundary of section. No fish of any kind were caught or observed.

Pilot Survey - T6N R9W Sec 4, 9, 16; T7N R9W Sec 33. From county bridge above Race Track Creek to next county bridge downstream on Hares Greenhouse Road. Length of section was 5.4 miles. No population estimate was made. Sampling was done simply to obtain an idea of the estent of the fish population. This section begins 8.7 miles downstream from the Anaconda Company waste treatment ponds at Warmsprings. Shocking results are given below.

Species	Number	Total Length (Inches) Range	Average
LL	124	2.8 - 21.6	10.9
Eb	2	6.9 - 8.3	7.6
Ct x Rb	1	10.6	10.6
RSS	59	-	-
FSu	6	-	-

Length-frequency analysis showed 6% of the brown trout caught were between 2.0 - 5.9 inches, 64% between 6.0 - 12.9 inches, and 30% between 13.0 - 21.6 inches.

Pilot Survey - T5N R9W Sec 7, 18. County bridge near Anaconda Company pH shack near Warmsprings downstream 2.2 miles to next county bridge. Section below A.C.M. settling ponds at mouth of Warmsprings Creek.

The sled boat shocker was used to sample the stream. No fish of any kind were collected with the shocker. Five small (3.9 - 6.5") longnose suckers were caught as they floated downstream. One small (4") sucker was observed swimming away from shallow water, as was one small (1/2") unidentified fry. One 6-inch dead and decomposing brown trout with tail missing was also found, but its origin is unknown.

Physical habitat throughout this section is excellent and should support fish. Physical habitat is apparently not the limiting factor in fish production.

APPENDIX D-2

DATA ON FISH POPULATIONS IN SELECTED TRIBUTARIES TO THE UPPER REACHES OF THE CLARK FORK RIVER

APPENDIX D-2

EXCERPTS FROM THE
MONTANA FISH AND GAME DEPARTMENT
FISHERIES DIVISION

JOB PROGRESS REPORT

State: MONTANA

Project No.: F-12-R-16 Title: Western Montana Fishery Study

Job No.: I-a Title: Inventory of Waters of the Project Area

Period Covered: April 1, 1969 to March 31, 1970

PROCEDURES

(See Appendix D-1)

FINDINGS - STREAMS

CLARK FORK RIVER

Lost Creek (06-3705) - Pilot Survey. A 400-foot section of the stream one mile west of the Warmsprings State Hospital was shocked to check on a fisherman's report that there were no fish in the stream and it looked "dead." A good, naturally reproducing brown trout population was found. The results are shown below.

Species	Number	Total Length (Inches) Range	Average
LL	41	3.2 - 19.6	9.2
Eb	2	4.5 - 5.5	5.0
Wf	3	15.7 - 18.1	16.6

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November 10, 1970

M E M O R A N D U M

To: Dr. Donald I. Mount, Director, National Water Quality Laboratory 6201 Congdon Blvd., Duluth, Minnesota 55804

Through: Dr. Gary L. O'Neal, Acting Chief, TA&I Branch

From: R. A. Wagner, Biologist

SUBJECT: Additional fish samples

For your records, on November 3, 1970 additional samples of fish for heavy metal analysis were collected from the major tributaries of the upper Clark Fork River. The pertinent information and data follow:

Tributary	Station Number	Sample No.	Species	Sex	Size	Remarks
Flint Creek	293034	1	Rainbow	F	12.5	Fat
		2	Brown	M	11.25	Not fat
		3	Whitefish	M	10 3/8	
		4	Whitefish	M	11	
Little Blackfoot R.	293033	5	Brown	F	11.5	Fat
		6	Whitefish	F	10 3/8	
		7	Whitefish	F	12 7/8	
		8	Whitefish	M	12.25	
Warm Springs Cr. (Powell Co.)		9	Brown	M	15.5	Not fat
		10	Brown	F	11	Not fat
		11	Brown	M	10 7/8	Not fat
		12	Brown	M	10 7/8	Fat
		29	Brown	F	17	Fat
Brock Cr.	293040	1	Small long-nose sucker			Cat ate
Lost Creek	293042	13	Brown	F	13 5/8	Not spawned-fat
		14	Brown	M	14 7/8	Half fat
		15	Brown	F	11 1/8	Half fat
		16	Brown	M	11 3/8	Half fat
		17	Brown	M	9 1/2	Not fat

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Tributary	Station No.	Samples No.	Species	Sex	Size	Remarks
Warm Springs Cr. (Deer Lodge Co.)	293029	18	Brown	F	10 7/8	Fat, eggs half dev.
		19	Brown	F	11	Half fat, eggs half developed
		20	Brown	M	11.5	Spawned
		21	Brown	F	11.5	Half fat-not spawned
		22	Brown	M	9.25	Immature -not fat
Racetrack Cr.	293041	23	Brown	M	9.25	Immature--half fat
		24	Brown	M	8 1/8	Immature--thin
		25	Brown	F	9	Immature--half fat
		26	Brown	M	6 3/8	Immature--half fat
Willow Cr.	293027	27	Rainbow	F	11 1/8	Immature--fat
		28	Brown	M	8 5/8	Immature--fat
Warm Springs Cr. (Anaconda Fish Hatchery) Montana Fish and Game	293025	six rainbows 7-1/8 inches long, probably two-year fish.				

With the exception of the scalpel blade none of the samples have been exposed to any metals other than those in the water.

Please let us know when we can expect the results of your analysis. If you have any questions, please ask.

R. A. Wagner

Wagner/m 11/1-/7

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

2a

TO : Dr. Gary O'Neal, Chief, TA & I Branch **DATE:** 9 January 1971

FROM : Director, National Water Quality Laboratory

SUBJECT: Analyses of Fish Tissues for Heavy Metals

On the attached sheet we have listed the concentrations of copper, zinc, lead, and cadmium we have found in the ten samples analyzed from the group you sent to us in late 1970. Our per cent recoveries for some of the samples are listed also.

As I recall our main purpose in doing these measurements was to see if edible portions of fishes living in waters contaminated by mine tailings might have unacceptably high metal concentrations for human consumption. We believe that the concentrations of copper and zinc found in these samples are within the normal range. The cadmium concentrations are also normal, and we believe this is to be expected because cadmium does not accumulate in muscle. Lead is the only metal which appears to be unacceptably high based on the lead tolerances used by the Food and Drug Administration for other types of food. Since the samples were very small, the instrument response measured was not large and there could be more error than desirable in these analyses for lead.

I would recommend that you make arrangements for the Corvallis lab to do additional lead analyses for you to better identify whether there is a problem in this regard.

We will retain the rest of the samples until we hear from you about their deposition.

Donald I. Mount, Ph.D.

Attachment

cc: J. Bouck
E. Leonard

D-2-4

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

RESULTS OF METAL ANALYSES OF TROUT TISSUES

Sample	*Copper ug/gm	% Recovery	*Zinc ug/gm	% Recovery	*Lead ug/gm	% Recovery	*Cadmium ug/gm	% Recovery
Flint Creek - #2	1.4	95.2	13.2	97.5	2.1	100.0	0.2	102.0
Little Blackfoot - #5	1.0	95.2	14.3	91.2	3.7			
Warm Springs - #19 Deer Lodge Co.	1.2	95.2	17.5	88.6	5.0	112.0	0.1	100.0
Warm Springs - #10 Powell Co.	1.1	104.8	15.4	106.8	4.0	100.0	0.2	
Lost Creek - #15	1.3	104.8	17.6		3.1		0.2	
Willow Creek - #27	0.8	104.8	15.5		4.0		0.1	
Racetrack - #25	1.0	104.8	14.6		2.9		0.1	
Clark Fork - Shipment #1	2.0	100.0	25.3		1.1		0.2	
Clark Fork - Shipment #2	2.5	95.4	13.8		3.5		0.2	
Clark Fork - Shipment #3	3.8	95.4	14.1		5.4		0.1	

* These figures are based on dry weights.

APPENDIX E

COPY OF LETTER
FROM
STATE OF MONTANA

STATE OF MONTANA

DEPARTMENT OF FISH AND GAME

Helena, Montana 59601
May 28, 1971

Mr. James Agee, Regional Director
Environmental Protection Agency
Water Quality Office, Region X
501 Pittock Block
Portland, Oregon 97205

Dear Mr. Agee:

This letter is in response to Dr. Gary O'Neal's telephone request for our estimation of where a suitable or desirable game fish population first occurs on the upper Clrak Fork River. The enclosed Completion Report for Job I-a of our D-J Project F-12-R-16 contains the latest summary we have printed on our Clark Fork shocking. Note this is for the period April 1, 1969 to March 31, 1970. Shocking data for the summer of 1970 has not been written up as yet.

On the basis of our shocking and some limited creel census data, we would consider the Clark Fork downstream from the mouth of Flint Creek, near Drummond, Montana, to contain a satisfactory game fish population, primarily brown trout. Thus, we could assume if you used the heavy metal concentrations that are occurring at Drummond as the limits for the Clark Fork in the vicinity of Warm Springs, the upper Clark Fork could eventually provide the same quality fishery from Warm Springs downstream as it does now below Drummond.

We feel the problem of heavy metals settling out with silt in dams on the Clark Fork should also be considered. The enclosed copy of our report on a recent siltation problem on the Clark Fork from a prolonged drawdown at Milltown Dam should explain our concern on this matter.

Sincerely,

ARTHUR N. WHITNEY
FISHERIES DIVISION CHIEF

ANW/eb
Encls.

E - 1

GPO 844-208